



CHARGING THE ENERGY REVOLUTION

**Fast Energy Storage is the Smart Grid
Enabler**

Joe Heinzmann
Senior Director
Energy Storage Solutions

> Altairnano Overview

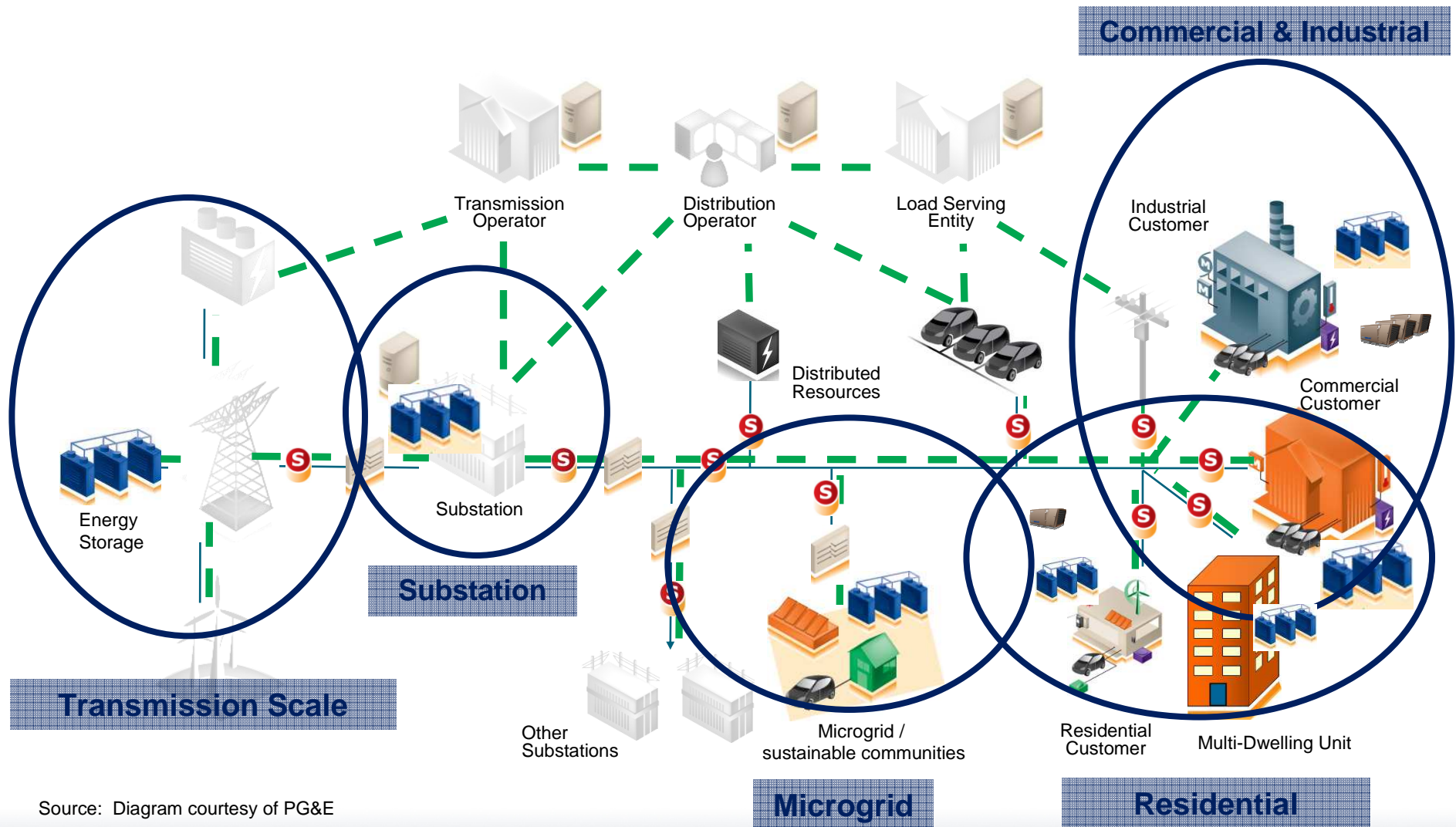
- **An innovator in nano-metal oxide-based materials**
 - Over 30 issued patents and 100 patent applications
- **A creator of niche applications for our unique battery technology**
 - Stationary Power
 - Transportation
 - Military
- **Large scale product manufacturing capabilities**
 - Facilities in Nevada and Indiana
- **Proven technology – Commercially operational for over a year**



➤ **Altairnano's Powerful Grid Stability Fast Energy Storage is Uniquely Suited to meet the Ca PUCs Smart Grid Requirements of:**

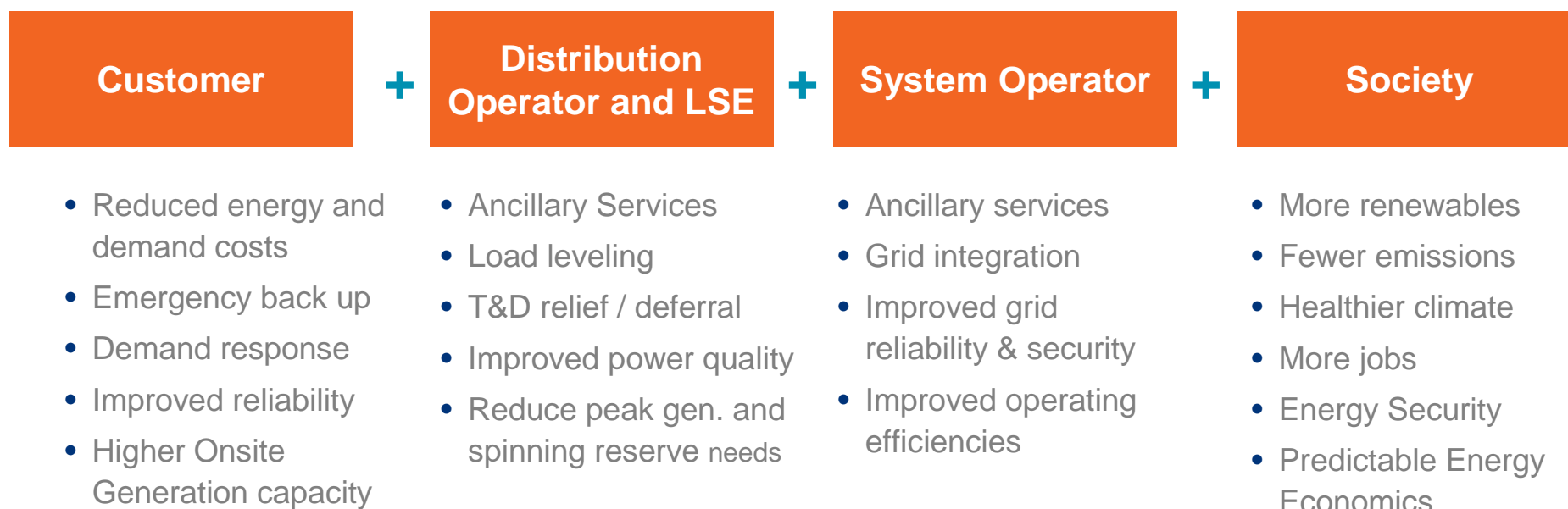
- **Increasing reliability, efficiency and safety of the power grid**
 - Fast energy storage becomes the safety net allowing line switching, higher generation and line capacities, and reduced outages
- **Enabling decentralized power generation so homes can be both an energy consumer and supplier**
 - Allowing higher penetration of renewable both on distribution and transmission lines without power quality compromises
- **Flexibility of power consumption at the consumer side to allow supplier selection**
 - Enables more cost effective use of onsite power solutions

> Storage is a Necessary Component of the Smart Grid

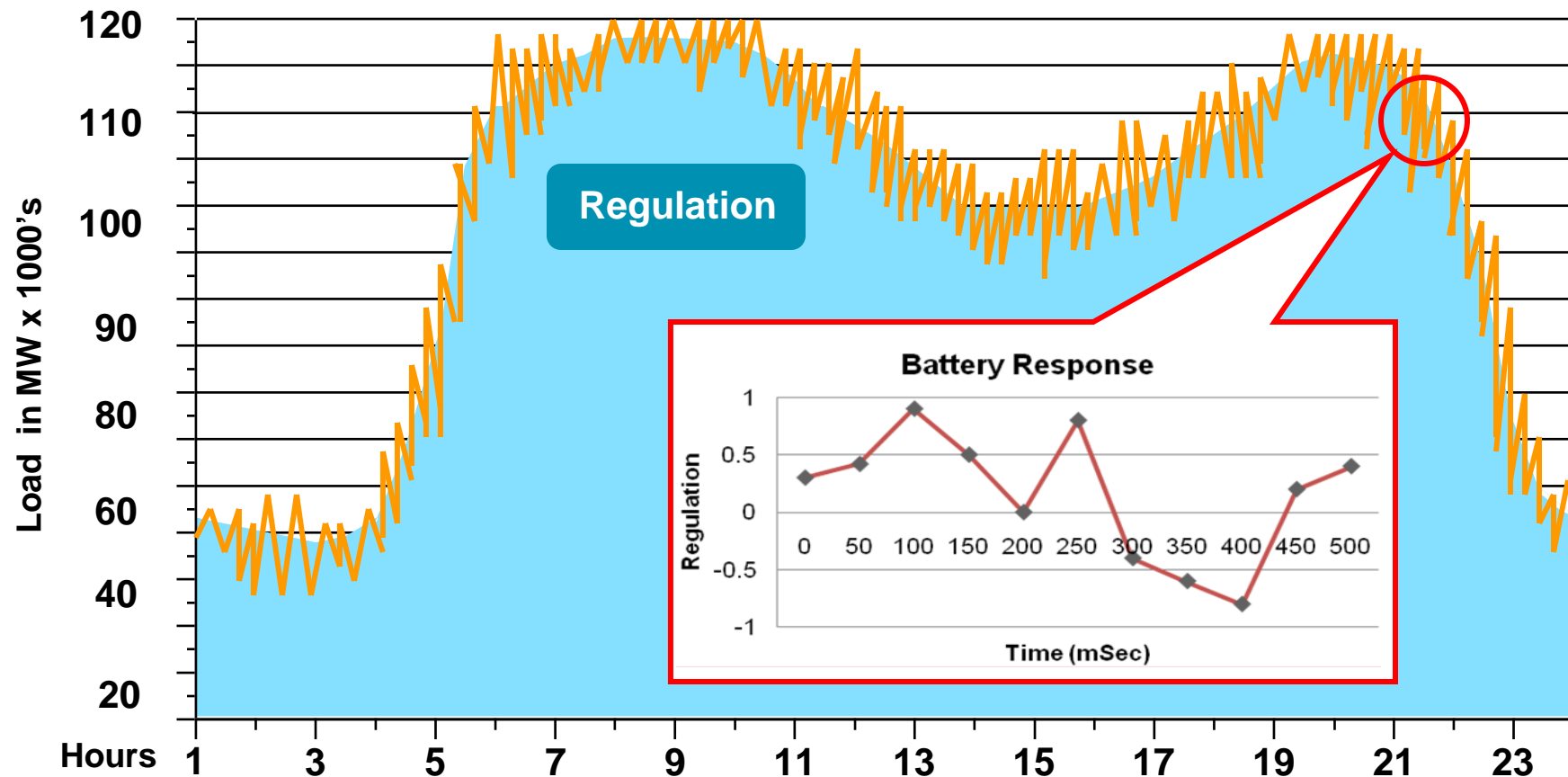


Source: Diagram courtesy of PG&E

➤ **Energy storage enables multiple value streams and a cost effective approach providing numerous benefits to many stakeholders**



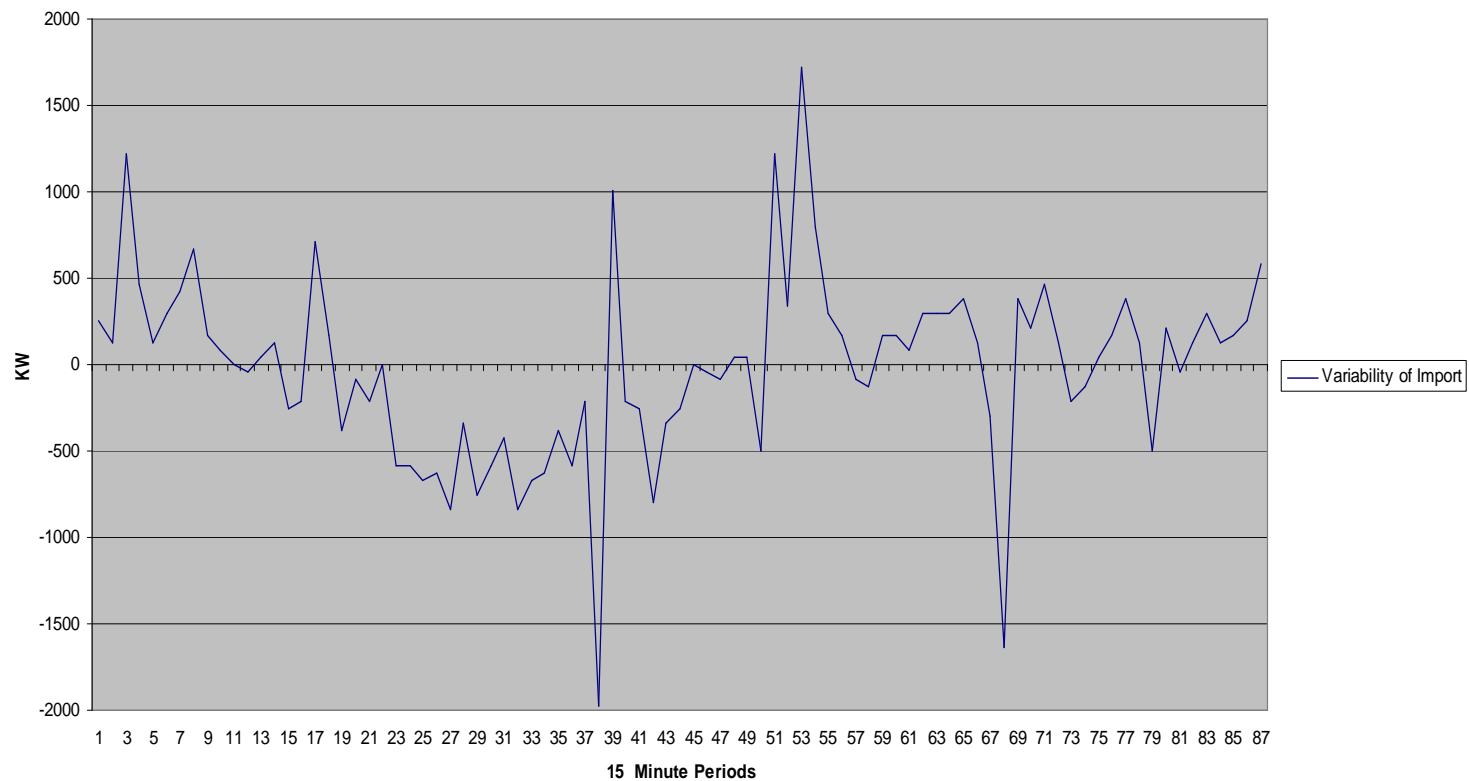
➤ Opportunities in Ancillary Services – Frequency Regulation



Utilities can predict very closely the demand expected from hour to hour,
but not from minute to minute

> One Day Transient Imported Power University of California San Diego 7000 KW Average Imported Power Oct 2008

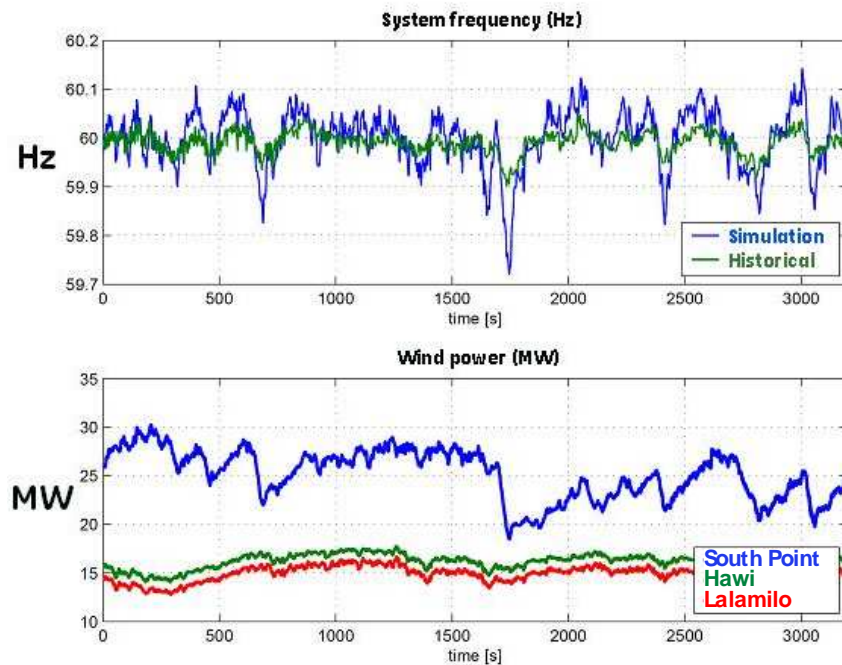
One Day Variability of Imported Power - Not Crossing PCC-Focus 2000KW or less



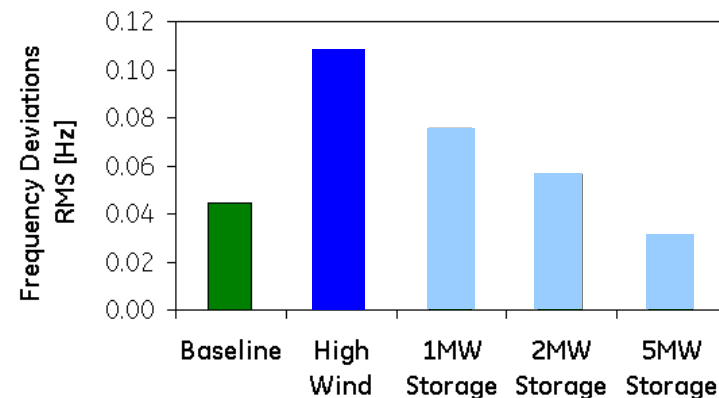
➤ Big Island Energy Roadmap Study

The Impact of 40% Wind Penetration
Need for Coordination With Fast-Reacting Resources

At 40% wind penetration, system frequency is severely affected



Incremental additions of "fast" energy storage increasingly stabilizes system frequency



5MW of "fast" energy storage resulted in similar frequency performance as the baseline scenario; near-term potential project

➤ Experts agree: Supporting storage aids renewable integration

“Enabling technologies such as fuel switching in ‘smart’ appliances, dispatch-able load from plug-in hybrid or other electric vehicles, or stationary energy storage would be required to enable very high levels of PV contribution (>20%) to the electric power system”.

- NREL Denholm & Margolis, April 2006

“When PV penetration reaches sufficiently high levels (e.g., 5 to 20% of total generation), the intermittent nature of PV can begin to have noticeable, negative effects on the entire grid”
[requiring storage]

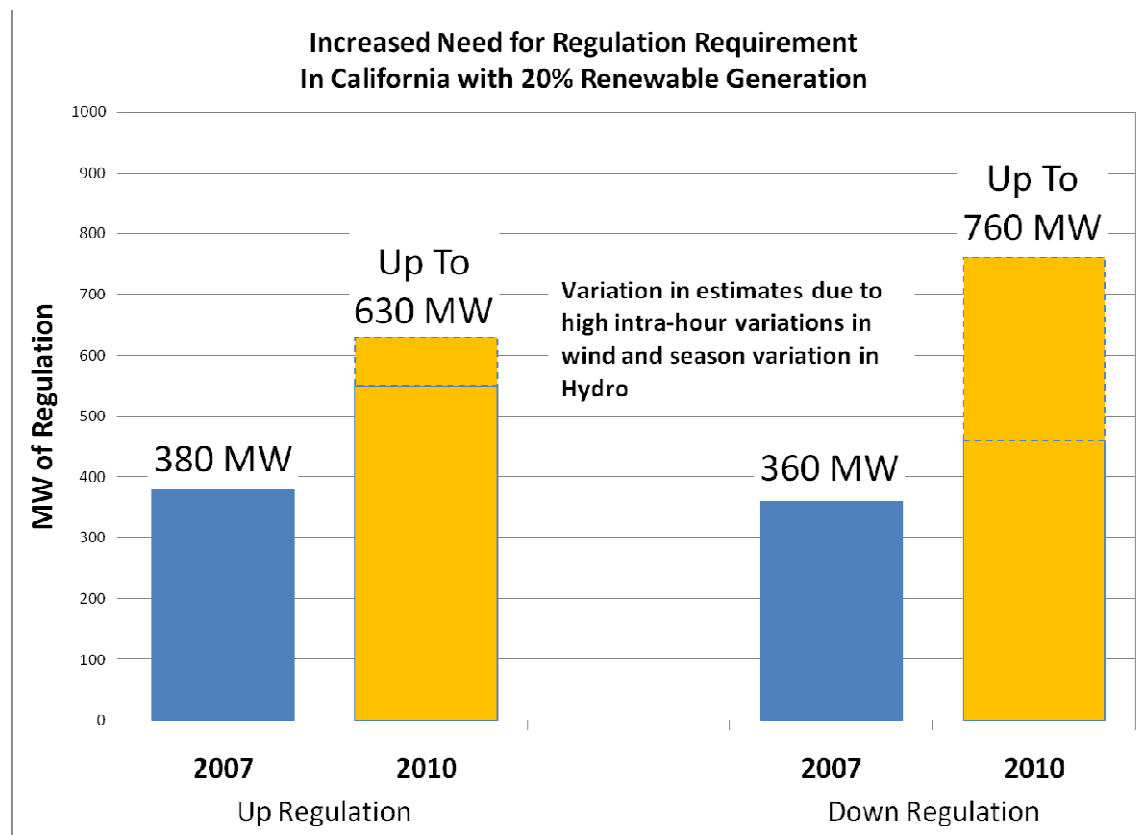
- US DOE, SEGIS-ES, July 2008

“Storage will need to be part of our portfolio if going to 15 to 20 percent wind at a national level, otherwise it won’t be efficient at a lower level and it won’t get us where we want to go environmentally”

- Electric Power Research Institute, March 2009

➤ Storage addresses the need for power regulation and ramping due to CA's RPS

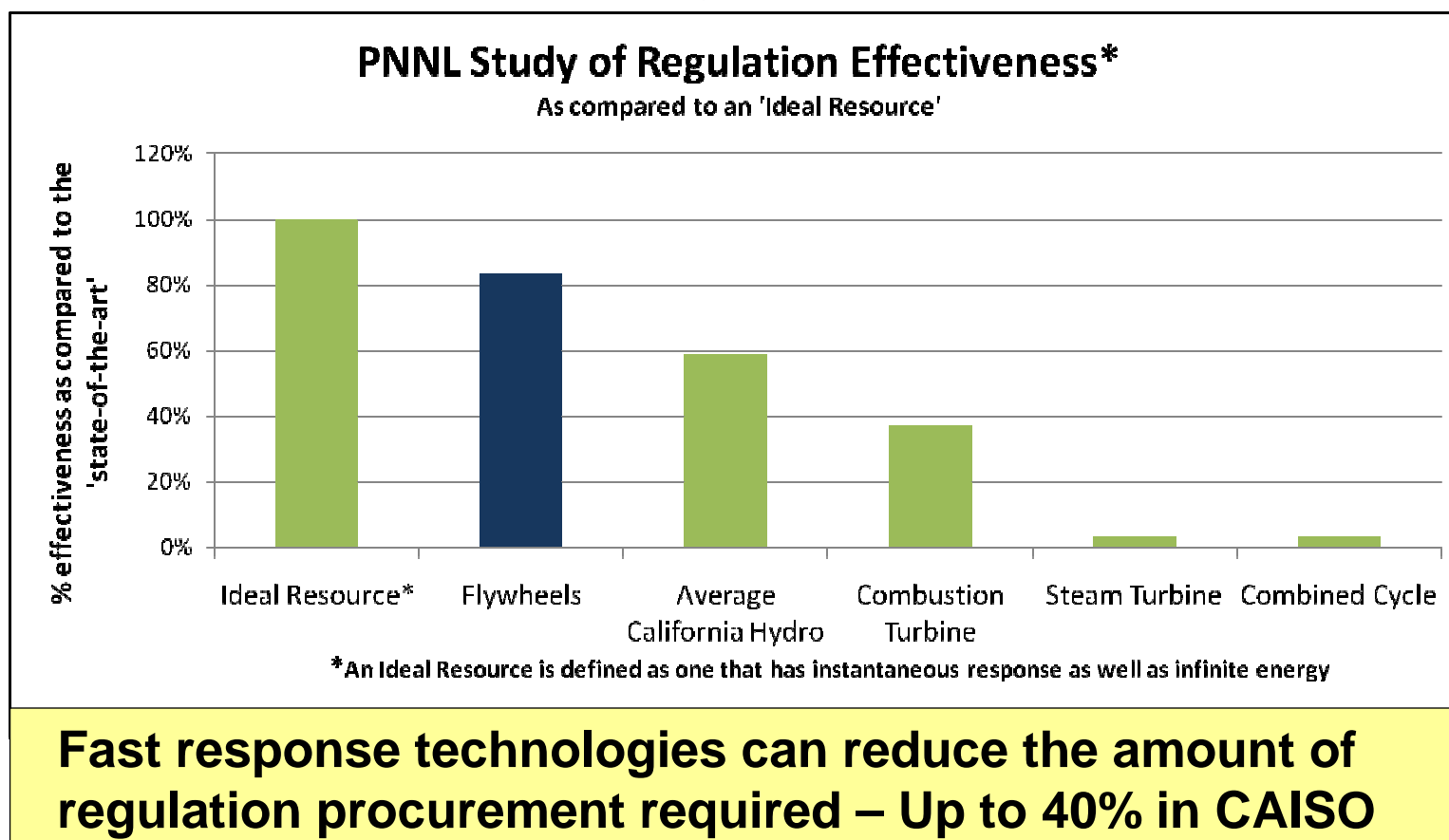
- Increased wind penetration creates need for greater regulation capacity and faster regulation ramping capability
- Nov '07 CAISO report identifies significant additional regulation requirements with 20% renewables (about 10% wind penetration)



Ancillary services can be provided today at 20 MW scale, and from systems as small as 1 MW on the customer side of the meter

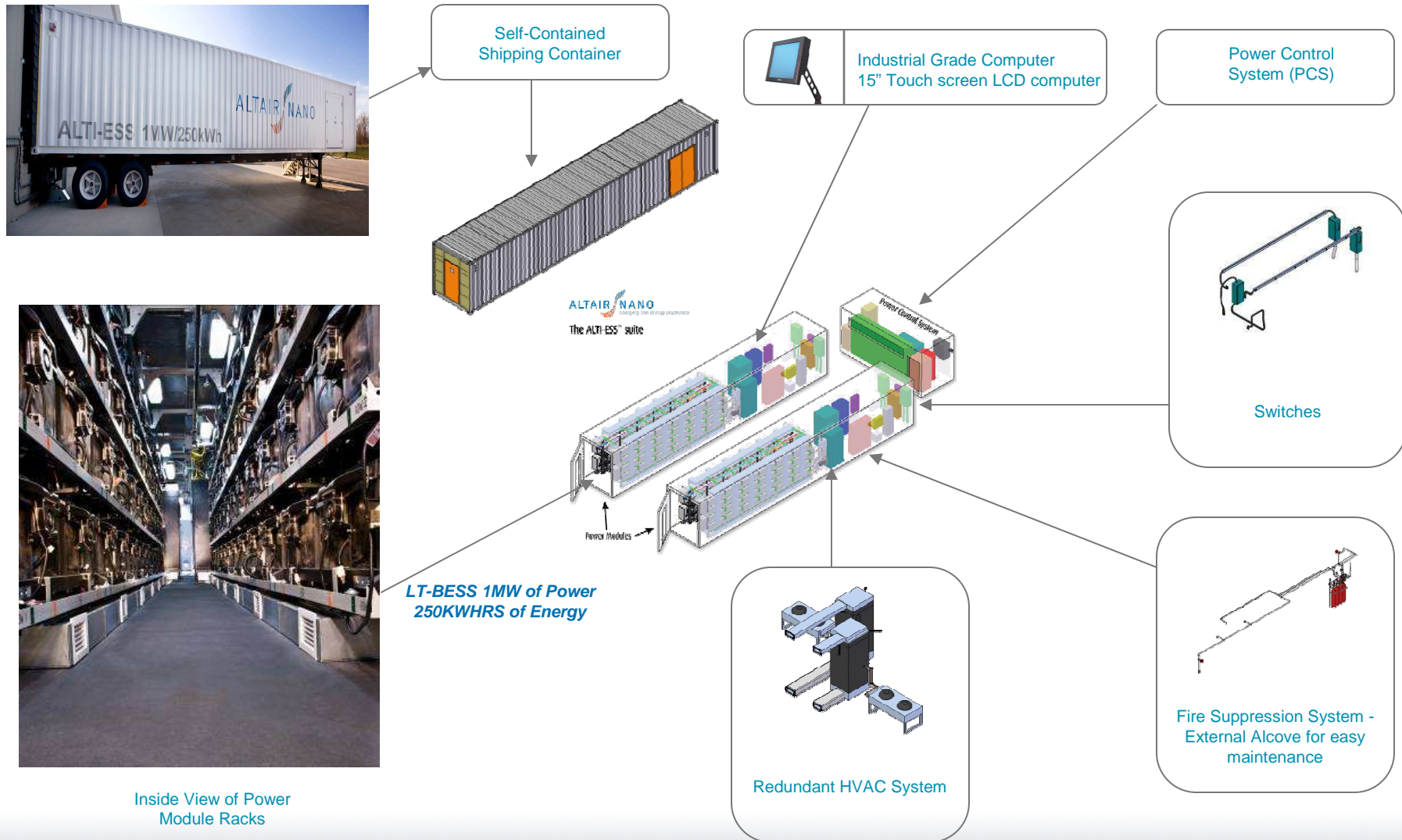
➤ Frequency error is function of the amount (MW) of imbalance and the time it takes to correct the imbalance

- The sooner ACE is corrected the less amount of regulation that is needed



*Source: Makarov, Y.V., et al. "Assessing the value of Regulation Resources Based on Their Time Response Characteristics." Pacific Northwest National Laboratory, PNNL – 17632, June 2008.

> Complete Solution for Utility Applications (2-53 Ft Cont. & 1-20 Ft Cont.)



➤ Cost Effective Grid Stability Altairnano Solutions

- **Instantaneous high power**
 - 20 Millisecond response time
- **Rapid Recharge Time**
 - 90% charge in 6 minutes
- **Significantly longer cycle life**
 - 12,000+ cycle life
- **Significantly longer calendar life**
 - 15 year calendar life
- **Wide operating temperature range**
 - -40° C to +55° C
- **Industry's highest roundtrip efficiency**
 - AC to AC of 86% to 91%

Altairnano's superior performance results in the cost effective application of storage in the Smart Grid



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Thank You – Questions?

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➤ Renewable Integration (Solar & Wind) – Solving the Interconnection Issue

- Wind and photo voltaic (PV) solar output is unpredictable and intermittent
 - PV can experience +/- 50% variation in output within 90 seconds
 - Wind can increase or decrease +/-30% in seconds
- Intermittency is a gating factor hindering renewable grid integration
- “Firming” of output is required to maintain grid stability
 - Will accelerate as utility-scale renewable penetration increases
- Instantaneous, high-power, rapid response capability of ALTI Energy Storage System mitigates the intermittency and “firms-up” the availability of renewable generation



➤ AES Development Project & KEMA Validation

- **AES Development Project - 2 MW Ancillary Services Unit**
 - 2 x 1 MW trailers
 - 2 MW for 15 minutes
 - Usable charge range 5% to 99%
- **KEMA Validation**
 - No design issues identified
 - Demonstrated suitability for scalable regulation applications
- **PJM Results**
 - 1 MW unit connected to the grid in PJM territory in May 2009
 - Providing commercial frequency regulation service with no major problems identified
 - Second 1 MW unit soon to be installed in ERCOT territory (Texas)

Prototypes were installed and demonstrated at substation owned and operated by Indianapolis Power & Light (IPL).



Validation testing by KEMA Consulting

Simulates peak response and spinning reserve applications as utilized by AES and similar energy providers

- Results show successful charge and discharge at full power for 15 minutes in either direction
- Exceeded round-trip efficiency expectations, retaining over 91% efficiency - this is unprecedented

➤ Commercial Validation in Mass Transit

- EV and HEV bus applications for municipalities and transportation authorities
- Selected by Proterra to deliver advanced battery modules for electric buses
 - Recent demonstrations achieved 17.5 mpg equivalent vs. 3.9 mpg for conventional diesel
 - Chosen for high cycle life, reliability, and safety
 - 10-minute charge, 9,000+ cycles at 100% depth of discharge
- Anticipate significant Proterra Follow-on order
- In ongoing discussions with other domestic & foreign bus manufacturers



Altairnano is at the forefront of large-format Lithium Ion battery development and demonstration

> Military – Current Projects

Office of Naval Research (Safety, Performance, Reliability)

- Awarded \$3.8M contract for Phase II of shipboard UPS system
- \$16.5M in total Federal Funding appropriated
- 2.5-Megawatt stationary power supply program
- Estimated \$1.5M annual fuel cost-savings per ship
- 960 metrics tons of carbon emission reduction per/ship per/year



M119 105mm Lightweight Gun Digitization Program (Safety, Temperature Extremes, Reliability)

- **Operating Temperature Range**
 - Only battery that can operate in both the cold mountains of Afghanistan and the extreme heat of the Iraqi deserts
- **Artillery Units**
 - Estimated 850 M119 guns in operation today
 - Heightened interest for other artillery applications



BAE Systems (Performance, Safety, Reliability)

- Altairnano completed first phase of program
- Contract valued at \$406,000
- A systems integrator that provides backbone to UK's Royal Navy fleet (includes Type 45 Anti-Air War Destroyer and Astute Class Nuclear Attack Submarine)

